WOODS HOLE OCEANOGRAPHIC INSTITUTION

WOODS HOLE, MASSACHUSETTS

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WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, Massachusetts

Reference No. 52-97

NORTH ATLANTIC OCEANOGRAPHY

under Task Order I

conducted during the period

July 1, 1952 - September 30, 1952

Periodic Status Report No. 25
Submitted to Geophysics Branch, Office of Naval Research
Under Contract N6onr-27701 (NR-083-004)

December 1952

APPROVED FOR DISTRIBUTION ____________
Director

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According to the terms of Contract N6onr-27701 (NR-083-004), the work to be performed by the Contractor shall consist of the following:

1. The Contractor shall furnish the necessary personnel and facilities for and, in accordance with any instructions issued by the Scientific Officer or his authorized representative, shall

(a) conduct research, analyze, and compile data and technical information, prepare material for charts, manuals, and reports, and foster the training of military and civilian personnel in the following fields of oceanography:

(i) permanent currents;
(ii) interaction of the sea and atmosphere (including wind waves, swell, and surf);
(iii) the distribution of physical properties;
(iv) the distribution of chemical properties;
(v) the distribution of organisms;
(vi) the characteristics of the sea bottom and beaches;
(vii) tides, tidal currents, and destructive sea waves; and
(viii) the physics and distribution of sea and terrigenous ice.

The research shall include, but not necessarily be limited to, the following:

(1) studies of North Atlantic Oceanography;
(2) wave observations and analysis;
(3) current measurements;
(4) studies of Arctic oceanography;
(5) development of unattended instruments;
(6) thermocline studies; and
(7) studies on inshore oceanography.

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INTRODUCTION

During the last several years an important objective of many of the cruises of our vessels has been to provide more uniform coverage of 900-foot bathythermograph observations over the North Atlantic as a whole. In this, of course, we have been greatly aided by the Project AMOS cruise of the ships operated by the Hydrographic Office. So far as other objectives permitted we have tried to visit areas which were not being crossed by the AMOS cruises.

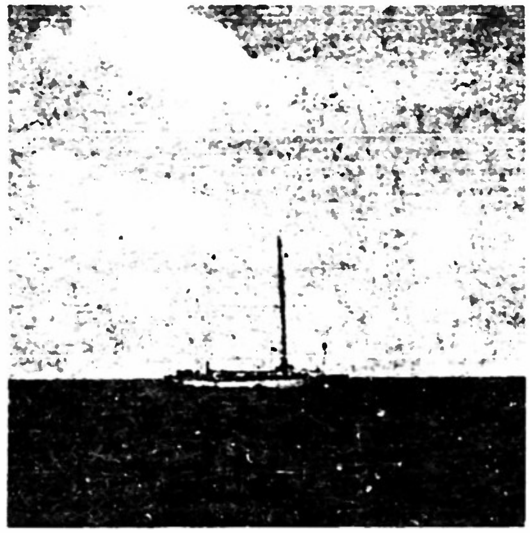
Thus, during the last year our vessels have been cruising in the trade wind latitudes, and it has been fortunate that this general plan of operation has coincided with the needs of the program in marine geology and geophysics of the Lamont Geological Observatory.

During the past summer the ATLANTIS has been cruising in company with the commercial tug KEVIN MORAN, which has been chartered by Columbia University. The vessels proceeded by various courses first to the Azores, then to Dakar, and then to Recife where they parted company late in September, the ATLANTIS proceeding southward along the coast of Brazil to Rio de Janeiro where Mr. Fuglister and others joined her for the return voyage. The ATLANTIS is expected back at Woods Hole about December 15.

This cruise will produce many bathythermograph sections across the Brazilian Current, the Guiana Current, and the Antilles Current, besides crossings of the Northern Equatorial Current for the first time during the summer months.

We feel that on her return to Woods Hole the ATLANTIS will have completed the exploratory phase of the superficial layers of the North Atlantic. This has been a work of many years and, of course, many other vessels have taken part, but it has been the 180-odd cruises of the ATLANTIS that have served to tie together the hundreds of thousands of temperature observations so that a consistent and comprehensive picture can be formed.

For reasons that have been previously stated in these Periodic Status Reports, the data are best summarized by a plot of temperature at 200 meters. Earlier editions of such a chart have been discussed. A "final" edition will be prepared after the return of ATLANTIS in December. We feel that this will be sufficiently reliable over the whole ocean so that our field work during the next several years can have quite different objectives. A renewed attack on the many



puzzling problems of the Gulf Stream is planned, as well as a study of shallow currents set up by the local wind.

The publication of the 200-meter temperature chart of the North Atlantic will be beset by problems of classification. It seems wise to discuss these briefly in advance so that those concerned can begin to consider how these difficulties might be resolved.

First of all, it should be emphasized that this chart will constitute a valuable contribution to science. It will be a very significant improvement over previous such charts, for example the one published in the "Meteor Atlas", in that more than ten times as many temperature observations will be available. In drawing the isotherms, only in few areas will interpolations of more than 60 miles be involved. Thus the narrow, swift nature of the permanent currents will for the first time be adequately shown. These currents divide the whole area into seven regions within each of which temperature at 200 meters only fluctuates by a degree or two, while at the boundaries changes of five degrees or more occur within a relatively few miles. These bands of closely spaced isotherms mark the average positions of the more powerful, permanent currents.

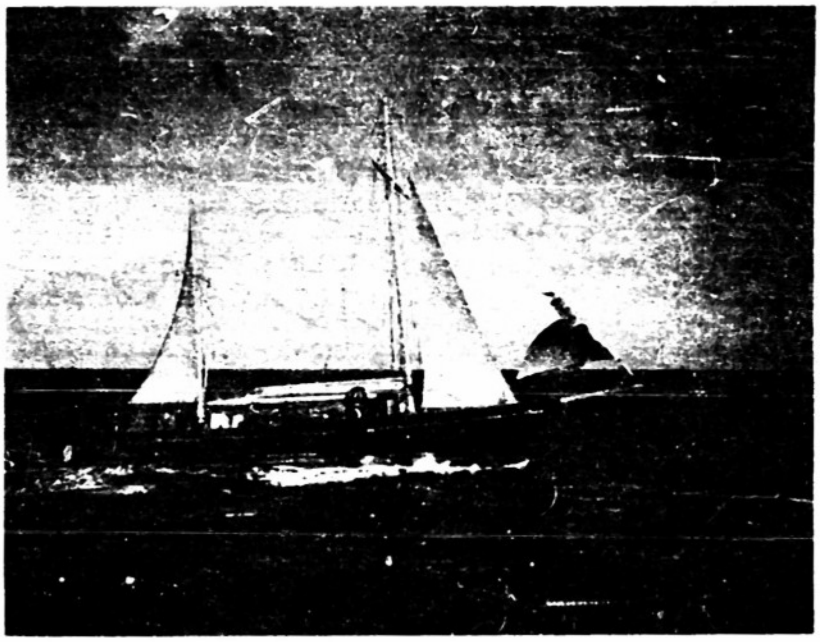
Although as a current chart it has some of the weaknesses of any statistical representation of the current system, in that short-term variations such as meanders and strong eddies are smoothed out, the effects of the local wind and of seasonal temperature changes are mostly eliminated. Now it will be the task of North Atlantic oceanographers to learn how to understand and to predict departures from the basic, average pattern of the current system. Thus the 200-meter temperature chart is expected to serve as the starting point in the development of synoptic oceanography.

Unfortunately, a reliable 200-meter temperature chart, when used in conjunction with readily available surface temperature data and some knowledge concerning the seasonal changes in layer depth, could become a fairly adequate substitute for Sonar Charts. By subtracting the temperature at 200 meters from published data on monthly surface temperatures or from on-the-spot observations, a good estimate of the temperature gradient between layer depth and 200 meters can readily be obtained. Thus in the hands of someone with a little oceanographic training it becomes possible to estimate the shape of the temperature-depth curve area by area and season by season. In short it can be argued that, by publishing the complete information now available for temperature at 200 meters over the North Atlantic, a part of the acoustical value of the complete file of bathythermograms would be disclosed. The chart does not, however, disclose the presence or absence of shallow sound channels.

Furthermore, it must be admitted that such a reliable chart of the stronger, permanent currents might become of some practical use to the navigator of a true submarine.

It is realized that the whole question of the classification of environmental information is under study. It is hoped that when the questions raised here are considered it will be realized that from the military point of view climatological data are only the first step. The synoptic situation in the sea is what influences the outcome of a given engagement, just as is the case in the atmosphere. Our 200-meter North Atlantic temperature chart shows only average conditions. Any oceanographer who has studied the already published data and is familiar with the modern oceanographic publications could reproduce its essential features.

From the scientific standpoint one great drawback of the bathythermograph has been the difficulty in publishing the wealth of temperature data it produces. European oceanographers are well aware of the quantities of bathythermograms that must be available. The few temperature profiles that have been published have simply whetted their appetites to see more. It has become a matter of serious embarrassment to American oceanographers that so few of the results of the bathythermograph have been made generally available. The publication of a 200-meter temperature chart summarizing thousands of these observations would greatly remedy this situation without, in our opinion, giving the important acoustical information away; namely, the shape of the temperature-depth curve season by season and area by area.



Research Vessel CARYN

NORTH ATLANTIC OCEANOGRAPHY

<u>Field Observations</u>. Besides the long cruise of the ATLANTIS mentioned above, on two occasions during the summer the CARYN and the BEAR became available for limited surveys. In July during a ten-day period they worked south of Woods Hole in and near the Gulf Stream. Here the main objective was to secure velocity-depth observations, both with the bathypitometer and with the conventional current meters (see below). Late in September the slope water area from south of Woods Hole eastward to Georges Banks was covered with a close network of bathythermograph and shallow

reversing water bottle observations. Both series of observations are at present being worked up.

Charting of Gulf Stream. A Transverse Mercator Chart was drawn up for the purpose of obtaining a new orientation in studying the Gulf Stream area. The equator of the projection was chosen to lie as near as possible along the mean course of the Gulf Stream in the region between 50° and 75° West longitude. This great circle reaches from 29° North and 85° West to 44° North and 25° West. With this projection the miles scale in the Gulf Stream area does not change appreciably from Florida to the mid-Atlantic region.

Continental Shelf and Slope Water. Mr. Sainsbury Strack completed the first draft of the study of the relation of surface temperatures and 100 and 200 meter temperatures in sections from the continental shelf out to the Gulf Stream. Mr. Strack has returned to Brown University to continue his studies. The report will be completed after Mr. Fuglister returns from his southern cruise.

File of Historical Weather Maps. Daily North Atlantic surface weather maps for the quarter have been added to the file. None of the gaps listed in the last quarterly report have been filled.

Comparison of Winds, Tide Gauge Readings, and Current. The work was resumed by Mr. Chase with the investigation of Miami tide gauge readings and some Gulf Stream transport data which appeared closely related to the work previously reported. A technical report is in preparation.

Although the tide gauge and wind data show some correlation with current data, it was indicated that allowances should be made for the effects of certain extraneous variables. This points to the need for a study of these effects. Future studies will greatly be aided by the continuous record of transport now being obtained in the Straits of Florida.

It was not found possible to correlate the Guiana Current and southeast trades observations with the other data. The available data of the slope of sea level from Cat Cay to Miami were studied but were not used in the report due to the numerous interruptions in the comparatively short Cat Cay record.

Current Measurements by G.E.K. Further studies of the slope of G.E.K. cables in tow have shown that the vertical area swept per unit time at given ship speeds is subject to variation. Some of this may be due to the variety of methods of measurement of the slope, but more may be due to small differences in the size and weight of electrode cases which it is found have important effects on the towing characteristics of different cables. The standard design employed at Woods Hole yields consistent experimental values of cable slope in the speed range 6 to 12 knots but these results do not compare closely enough with the field results obtained by WHOI, SIO, and POFI, Honolulu, to permit all observations near the magnetic equator to be corrected in the same way. For this reason it is considered advisable that G.E.K. cables be held level so that corrections are unnecessary.

It is found that the interelectrode length of a standard G.E.K. cable will remain on the sea surface at speeds as high as 12 knots if buoyed by eight commercial foam-plastic fish net floats, the size and shape of ordinary footballs. These are distributed according to the parabolic relation $2x^2 = y$. Beginning at the more distant electrode the distribution becomes 0, 2, 8, 18, 32, 50, 72, and 98 meters. The length of cable between the nearer electrode and the ship can be held on the surface by placing floats at 2, 18, 50, and 98 meters. The parabolic distribution appears to work best and was chosen because the cable is well supported at the ship end and slopes downward most rapidly along the length of cable immediately upstream from each electrode. It is found that the buoyancy and distribution of the floats must be such that the floats ride on the sea surface approximately in trim. If the floats tend to nose downward they are towed under as the ship gathers way and do not rise again until the ship is stopped.

The fish net floats used in these experiments were purchased from the Sponge Rubber Products Company in Shelton, Connecticut. The floats contain a fair sized hole along their length which is plugged with chemical rubber stoppers bored to fit the G.E.K. cable and cemented in place with Bostik. The drag of cables so equipped is not excessive at ordinary cruising speeds. It is noted that cables so buoyed may not need to be brought aboard while the ship is occupying hydrographic stations, and that a buoyed cable is much easier to haul in when that becomes necessary. The float system is considered to be only a partial solution of the level cable problem since it is not adaptable to being towed below the surface. It is recommended that level cables be used generally for surface G.E.K. measurements and especially for studies of current systems within 30° of the magnetic equator.

The Appearance of the Sea Surface from the Air. The increasing availability of aircraft for oceanographic surveys suggests that there is much to be learned if meaning can be assigned to the abundance of visible patterns of reflection, water color, weed, and wave structure that can be observed on the sea surface from the air. To an observer in a low-flying airplane these features pass so quickly before him that he has neither time to digest his observations nor clear enough memory of them to consider them in retrospect. On occasions when long over-water flights have been made in areas surveyed by ships, it has seemed possible to correlate major slick patterns and changes in the sea state and cloud cover with the sea surface temperature and current patterns. It would be desirable to learn the extent to which these correlations are reliable.

With this aim in mind, Mr. von Arx built a prototype time-lapse motion picture camera which includes in its field of view nearly 1.2 radians (a second model includes 2.0 radians). As this camera is installed at present, it is aimed directly ahead at the horizon so as to reduce the apparent motion of the airplane and the sea as much as possible, and record both the sea and sky. The point of view being at low angular incidence to the sea surface, slick patterns stand out strongly but, at the same time, the wave and weed patterns are resolved on the lower portion of each frame. Pictures are taken at the rate of 72 per minute which permits the finished films to form an intelligible review of the flight at fifteen times normal speed. One hour's flying time is recorded on 100 feet of film.

The optical train employed consists of a surplus Mark 71 telescope placed wrong-end-to before a Bell and Howell 16 mm. magazine camera. The field of view of the optical system is equal to the apparent field of the eye piece which serves as an objective for the system, but the aperture stop of the camera lens serves as the aperture stop for the optical train. Thus exposures may be computed on the basis of the diaphragm setting of the camera lens provided suitable allowance is made for the light loss along the length of the optical train. The latter amounts to approximately 50%. Since the focal plane of the eye piece is the site of a real image it is possible to insert at this point small slips of translucent celluloid on which notes may be written concerning the progress of the flight. These notes appear on the film.

The need for an involved optical train in wide-angle Cine photography from aircraft arises from the fact that the shutter and film transport mechanisms of 16 mm. motion picture equipment prevents the design of truly wide field objectives. The equivalent focal length of the apparatus in present use aloft is about 7 mm. or nearly half of that of the shortest focus commercial wide-field Cinè objective. Due to the length of the optical system, about 3 feet, it is possible to place the objective outside the airplane and still operate the equipment comfortably from within. A little study of the properties of modern wide field eye piece designs indicates that the principle defect they possess is curvature of field. This does not prove troublesome if the aperture stop does not exceed 5 mm., corresponding to a stop of f3 on a Cinè objective of 15 mm. focal length. By neglecting distortion true fields of 115° have been accommodated when the design is pushed to practicable limits. A continuous record of time, altitude, and course, may be incorporated in the field of view of the camera.

Repeated study of the films that have already been made from the PBY-683 over local waters and the Gulf Stream has shown that many details and some large features of the sea that can be observed from the air escaped notice completely during the flight. It is hoped that when enough observations have been made from the air in regions surveyed by ships, the visible evidences of oceanographic and meteorological occurrences at sea may be more readily interpretable and that a preliminary reconnaissance from the air may eventually be of use in planning subsequent work from ships.

ARCTIC OCEANOGRAPHY

Arctic Field Observations. Mr. Worthington was engaged in analyzing and reporting the scientific results of Project SKIJUMP which was carried on during the past two winters. One of the more interesting results of this project is the apparent evidence of a large anticyclonic eddy in the Arctic Ocean to the north of Alaska. Although the figure still must be considered as very tentative, dynamic calculations indicate the volume transport of this circulation to be in the neighborhood of 3.75×10^6 cubic meters per second relative to the 2000 decibar surface. A report on the scientific results was in the last stages of preparation at the end of the present quarter.

In addition to the above Mr. Worthington was engaged in preparing for a period of field observations aboard T-3, the "ice island" floating in the North Polar Basin. At the close of the quarter Mr. Worthington and his oceanographic equipment were in Thule, Greenland, awaiting air transportation to T-3 which at the time was at 87° North, 88° west.

During part of the third quarter Mr. Metcalf continued his work on the oceanographic data, collected during the previous winter on board the USS ATKA (AGB-3) and USS EDISTO (AGB-2). However, during almost two months of the period, Mr. Metcalf has been on leave from Woods Hole while working on a project at the Massachusetts Institute of Technology. The work on the cruise data is continuing under the guidance of Miss Tollios.

Relations between North Atlantic Ice and Arctic Weather. Maps of the decadal pressure distribution over the Atlantic-Arctic and adjacent areas covering the period 1901-39 (see below) were completed by Mr. Schell. Figures 1 - 8 show both the absolute pressures as well as the departures from normal (1901-39) for the three full decades 1901-10, 1911-20, 1921-30, and the incomplete decade 1931-39.

The main feature of the pressure regime during this 39-year period is the northerly displacement of the North Atlantic low pressure system for the period 1921-30, 1931-39, the displacement for the period 1931-39 being the greater of the two. The movement of the low pressure system north during 1931-39 appears to have been associated with a northerly movement of the fringe of the North Atlantic high as indicated by the positive departures far to the north (Fig. 8). Thus, the northerly shift of what may be called the North Atlantic pressure system is another link in the chain of evidence of a northerly shift of the air and water circulation, including the southerly limit of the Arctic ice (see earlier Periodic Status Reports).

Ice Reconnaissance. During August Mr. Schell made a visit to Iceland, a country that has long been concerned with the problem of Arctic ice, to discuss the possibility of a wider program of ice observations and to check on current oceanographic and meteorological activities there.

Talks were held with Th. Sigurgeirsson, Secretary of the National Research Board, T. Gudmundsson, Director, and J. Eythorsson and H. Sigtryggsson of the Meteorological Office, U. Stefansson, University Research Institute and others. In addition problems were discussed with Major Ashworth, Commanding Officer, Flight C, 6th Air Rescue, USAF, based on Keflavik. The Langjökul glacier was visited to observe signs of that glacier's recession in the past two decades and, at

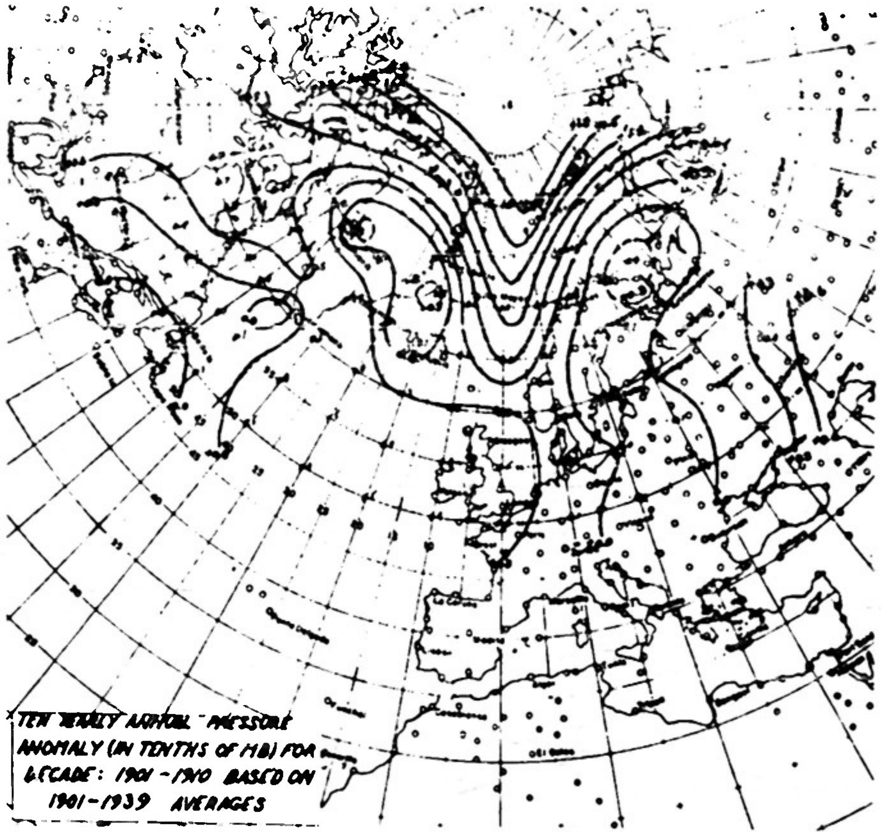

TEN YEARLY ANNUAL PRESSURE
ANOMALY (IN TENTHS OF MB) FOR
DECADE: 1901 - 1910 BASED ON
1901-1939 AVERAGES

FIG. 1

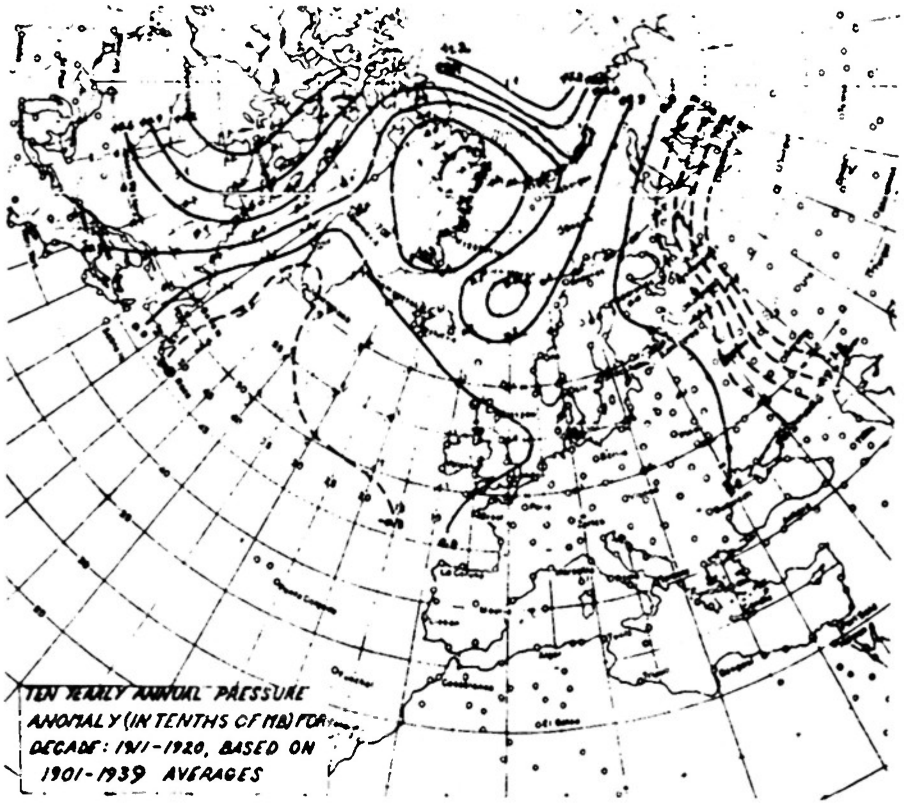

TEN YEARLY ANNUAL PRESSURE
ANOMALY (IN TENTHS OF MB) FOR
DECADE: 1911-1920, BASED ON
1901-1939 AVERAGES

FIG. 2

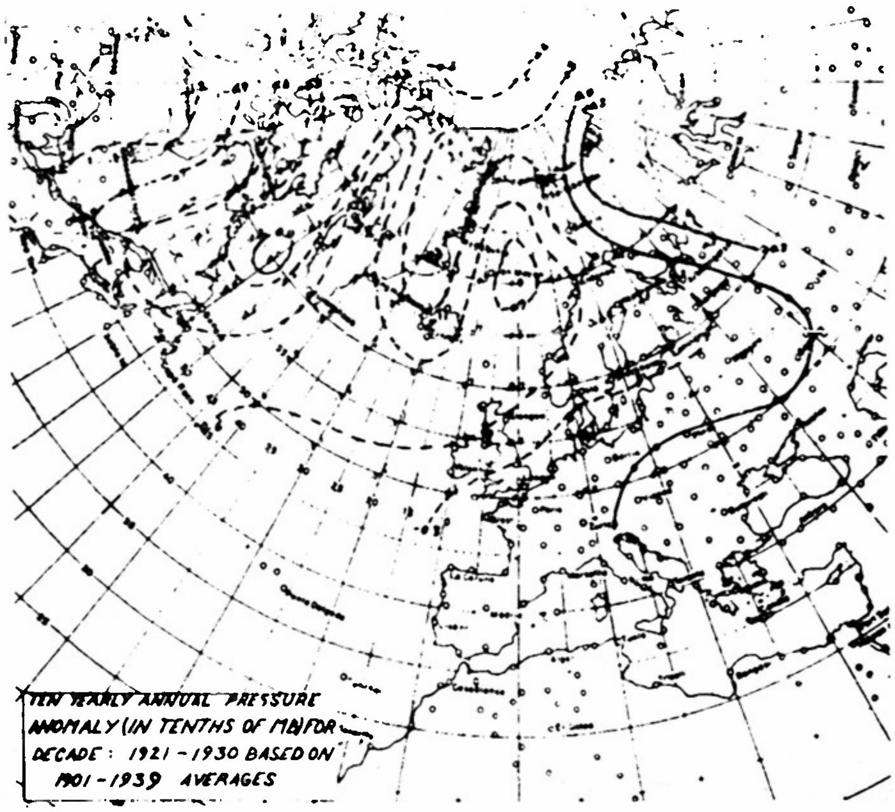

TEN YEARLY ANNUAL PRESSURE ANOMALY (IN TENTHS OF MB) FOR DECADE: 1921-1930 BASED ON 1901-1939 AVERAGES

FIG. 3

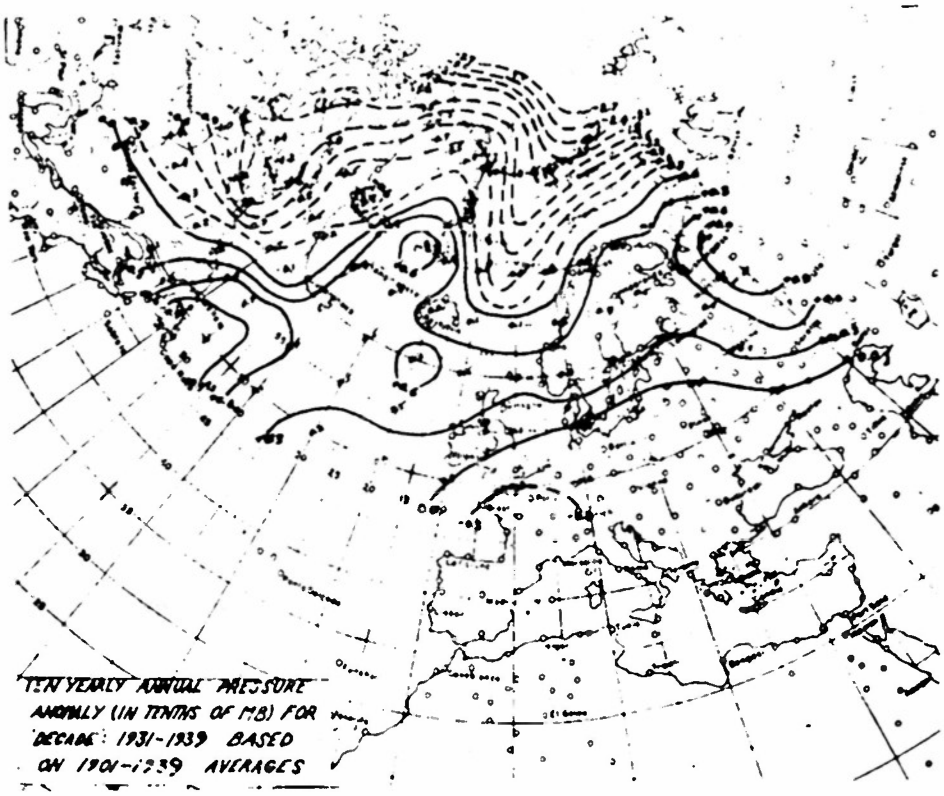

TEN YEARLY ANNUAL PRESSURE ANOMALY (IN TENTHS OF MB) FOR DECADE: 1931-1939 BASED ON 1901-1939 AVERAGES

FIG. 4

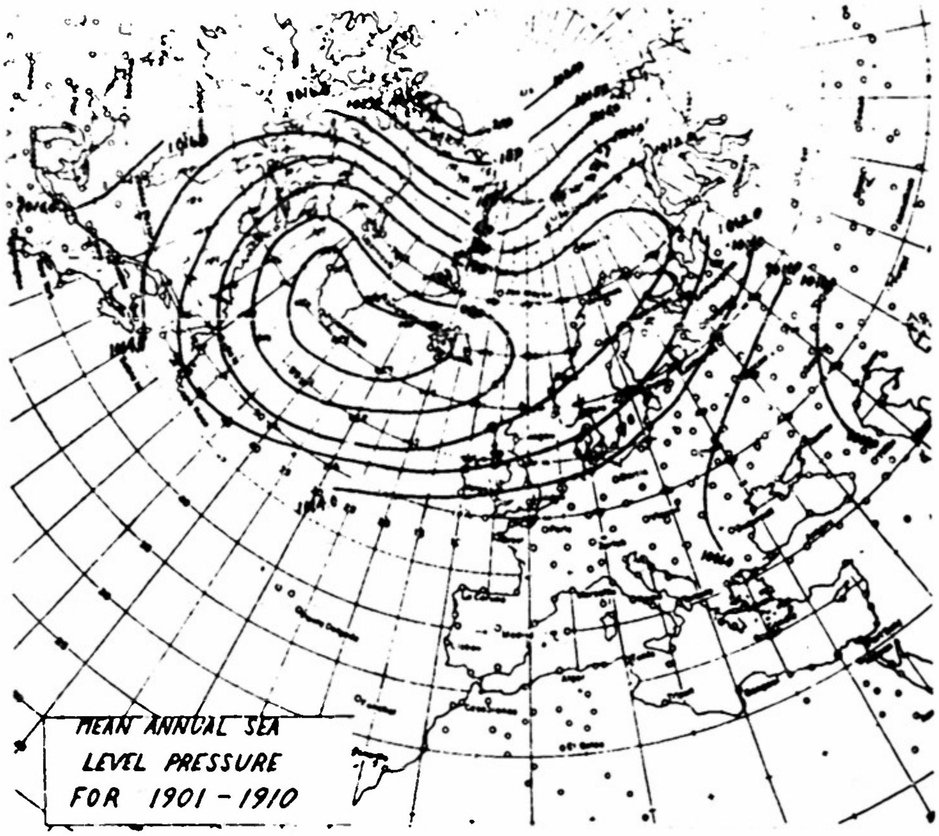

MEAN ANNUAL SEA
LEVEL PRESSURE
FOR 1901 - 1910

FIG. 5

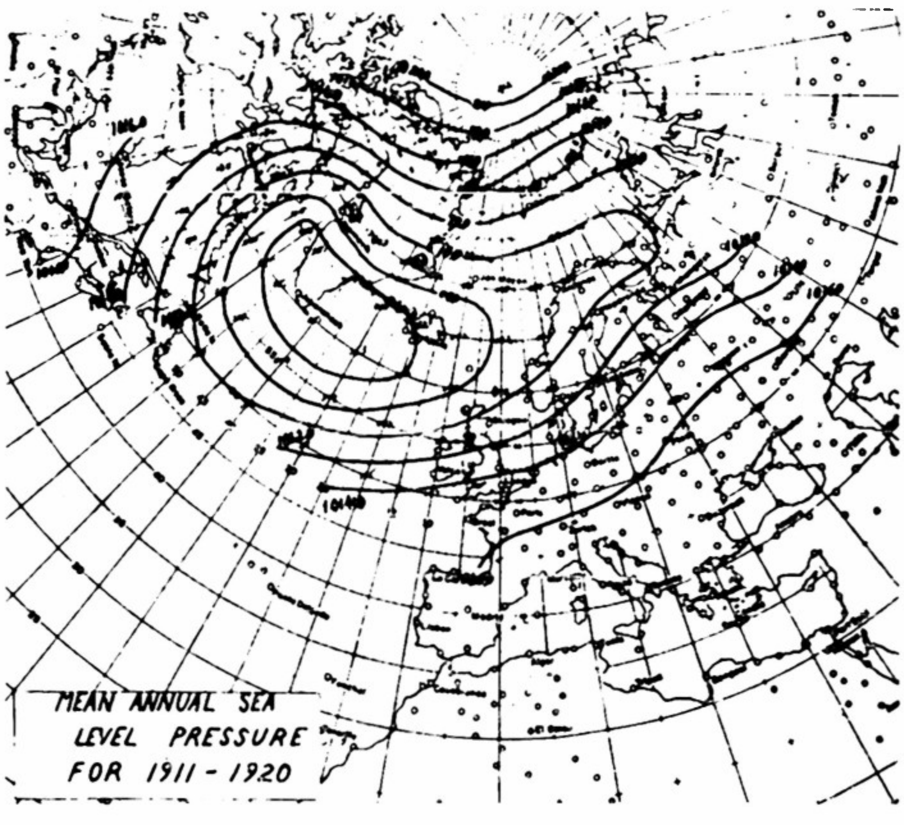

MEAN ANNUAL SEA
LEVEL PRESSURE
FOR 1911 - 1920

FIG. 6

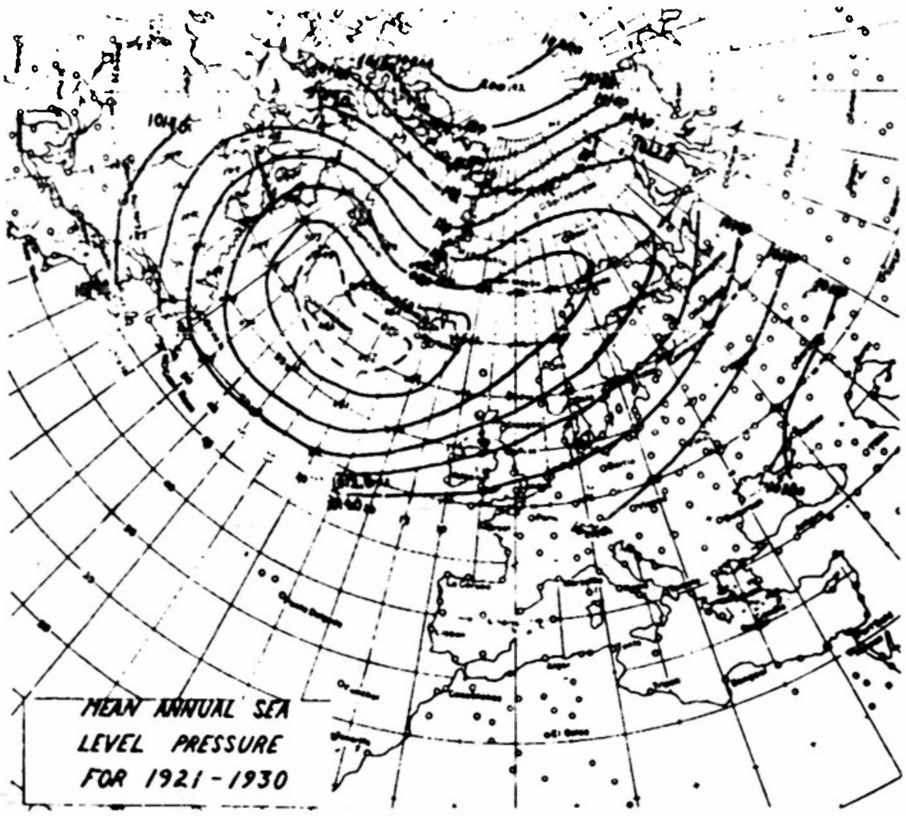

MEAN ANNUAL SEA
LEVEL PRESSURE
FOR 1921-1930

FIG. 7

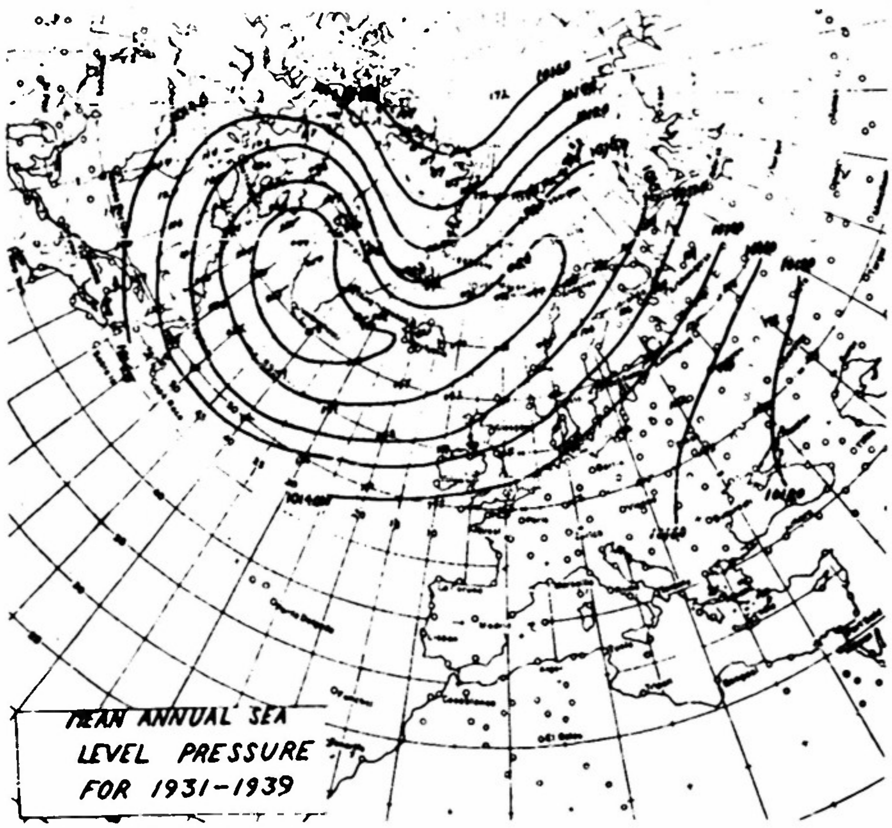

MEAN ANNUAL SEA
LEVEL PRESSURE
FOR 1931-1939

FIG. 8

the invitation of T. Sigurgeirsson, Mr. Schell lectured at the University in Reykjavik on the progress of our research in interrelations of Arctic ice with the weather.

Scientific endeavor in Iceland has received much stimulus in recent years. Lying athwart an important international air route to the Arctic and another between North America and Europe, and also figuring prominently in North Atlantic military strategy, Iceland has been called upon to shoulder enlarged scientific responsibility. Last but not least Iceland also has had to meet demands for the solution of a variety of its own scientific problems. As a result, Iceland's scientific and technical services have lately been considerably widened.

The expanded program of oceanography includes the making of a number of cross sections during the three summer months. A section from a point on the northwest coast in a northwesterly direction to as far as the ice lies is made early in the season, while another is made farther out when the ice has receded; a section from a point on the north coast due north, a third section from Langanes on the northeast coast to Jan Mayen, and still another, also from Langes, due east. The northwesterly directed section first cuts across the branch of the Irminger Current, sweeping eastward along Iceland's north coast and farther out, across the East Greenland Polar Current flowing westward or southwestward. The northerly directed section cuts across Irminger Current water that has had an admixture of cold Arctic water. The section extending northeasterly to Jan Mayen first cuts across the East Iceland Polar Current and thence across North Atlantic warm water from the southeast, passing on the southwesterly side of Jan Mayen. Finally, the section due east cuts across the East Iceland Polar Current at a point farther down the stream that is headed into the main flow of North Atlantic warm water, which in turn is headed northeastward.

Our discussions of recent data brought out the fact that a notable and perhaps decisive change occurred in recent years in the mild meteorological and oceanographic environment of Iceland that has prevailed beginning with the 1920's. Ice has reappeared in strength along the northern coasts of Iceland in 1944 and in 1949. The ice has also approached close to the land in 1951 and, it would seem, again in 1952. Much cold Arctic water reached Iceland in 1949 (no hydrographic cross sections were reported for 1944). The intensified East Icelandic Polar Current in 1949 appears to have been responsible (Hermann, 1951) for the weak North Atlantic oceanic influence the following year in the Shetland-Faroes area. Colder than usual water appeared also in 1951. At the same time, recent air temperatures over Iceland have been averaging well below the normal and the precipitation has fallen off considerably in keeping with a colder climatic trend for that type of region (Schell, 1952). Insofar as glacier movements are concerned, it appears that, while the majority of the Icelandic glaciers are still receding, the proportion of those advancing has been greater during the past four seasons (ending with 1950-51) than previously. It is to be noted that the response of glacier movements to the weather must of necessity be delayed.

The specific question of Arctic ice reconnaissance was discussed in considerable detail. Because of the adverse effect a return to severe ice conditions and associated weather and water temperatures, etc., would have on different phases of Iceland's economy and well being*, interest in a fundamental program of ice observations and research is very marked. It was agreed to plan air reconnaissance next spring and summer "if and when the ice gets close to Iceland". It is obvious, however, that the resources of the country (population 155,000) are too slender to support a program of ice reconnaissance on the scale needed. The position of the southerly limit of the Arctic ice requires determination over a wide area.

Fortunately, the interest of the Icelanders in a broader program of Arctic ice observations appears to coincide with Major Ashworth's interest in providing his group of flyers with Arctic ice experience. (A sizable proportion of the Air Rescue missions is directed north of Iceland over the ice). It was agreed to plan as many ice observations as possible for next spring and summer. One ice mission was arranged during Mr. Schell's visit, flying to the east coast of Greenland (68°40' North, 26°25' West) and thence to Scoresby Sound and King Haakon Fjord.

The range of the plane used (Grumman-Albatross) is only a little better than 1000 miles. Although this type of plane is adapted for landing on the ice (as well as water) and could be used for detailed ice observations, it can only fly a little better than half the distance to Spitsbergen before it would have to turn back. For observing the ice over a wide area, a plane with a greater range would be required.

To gain full benefit from the proposed ice flights it would be necessary to give the air crews information on the

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* Traditionally severe ice conditions is one of the three plagues of Iceland, the other two being volcanic eruptions and earthquakes.

more common types and features of Arctic ice. A rather simple ice code needs to be prepared. Also a series of photographs in color of the more important ice types and ice features should be made available as part of the air crews' instruction in making ice observations. It must be admitted at the same time that partly because of the normal duties of the plane crews and frequent rotation of military personnel, only limited results can be expected in these circumstances from the ice missions. For a really effective program of Arctic ice observations, someone with a knowledge of Arctic ice who, moreover, has had some training in oceanography and meteorology and who could devote his entire attention to observing the ice, is needed to go along on each flight. This person may be called the ice officer of the flight, and would be required to spend some six months on the ice tour, from about the end of March when the ice extent is at its maximum to about the end of September when it is at a minimum. While stationed principally at Iceland, the ice officer could whenever possible go to Goose Bay, Thule, etc., to make ice reconnaissance from there. The rest of the year might be devoted to digesting the information obtained, preparing reports, and studying the problem of Arctic ice in general. In this way effective observations of the southerly limit of the ice in the Atlantic-Arctic would become available.

The impression was gained that the current observation and research program in Iceland closely ties in with our own Arctic research. Continued exchange of information between us and Iceland is desirable.

References

Hermann, F., 1951: Hydrographic Conditions in the Southwestern Part of the Norwegian Sea, Ann. Biol. (C.P.I.E.M.), v. VII (1950), pp. 13-18.

Schell, I. I., 1952: W.H.O.I. Reference No. 52-61, Periodic Status Report, April 1 - June 30, 1952.

DEVELOPMENT OF INSTRUMENTS

<u>Unattended instruments</u>. A cruise was made on the BEAR with the intention of laying three Klebba 400-day temperature recorders at various depths on the shelf, to be recovered by dragging. The technique involved attaching the instrument

to about a mile of cable, location to be determined solely by Loran fixes. A practice drag with rather crudely improvised gear made the method look promising, and one instrument was placed at 20 fathoms. The remaining instruments proved to be defective, and so were not placed upon the bottom. However, dummies for later recovery were placed at 40 and 80 fathoms. Two subsequent attempts were made to recover the instrument and the dummies, without success, and on the basis of this experience an adaptation of the Gifford Grapnel, used by Western Union, is now being made.

The unsuccessful attempts at recovery also indicated the necessity of using a ship which can be slowed down to one knot for dragging operations, and of having an acoustic signalling device on the instrument rather than relying only on Loran. Interrogation of Nantucket Loran station personnel indicates that possible errors require the search of a four mile circle to re-establish the instrument position; a tedious and expensive operation.

The design of an explosive-actuated release device for deep water recovery has been completed by Mr. Frantz, and construction of components is under way. Both the deep water technique and grappling with improved equipment will be attempted in the near future.

Submarine Cable Connected Electrodes. The electric potentials across the Straits of Florida, as measured by a submarine cable loaned to us by the Western Union Telegraph Company, has now been successfully carried out for two months. The indications are that the Straits of Florida are a particularly favorable location for making electromagnetic measurements of the transports of ocean currents.

Mr. Gunther Wertheim, who set up the electrodes and observational procedure at Key West, is continuing on a part-time basis to supervise the project. Preliminary comparison of the transports indicated by the electrodes to those expected on the basis of oceanographic data have been carried out by Mr. Stommel. Figure 9 shows three hour averages of the electric voltage between Cojimar, Cuba, and Key West, Florida, from the 1st to the 20th of August 1952. The voltage (which is proportional to the transport through the Straits) is subject to variations of a semidiurnal tidal period. Comparison of these to the magnitude of the averages expected from the progress of semidiurnal tide from the Atlantic into the Gulf of Mexico indicates that there is very little effect due to the conductivity of the bottom in the Straits of Florida. During the period indicated in Figure 9 the transport

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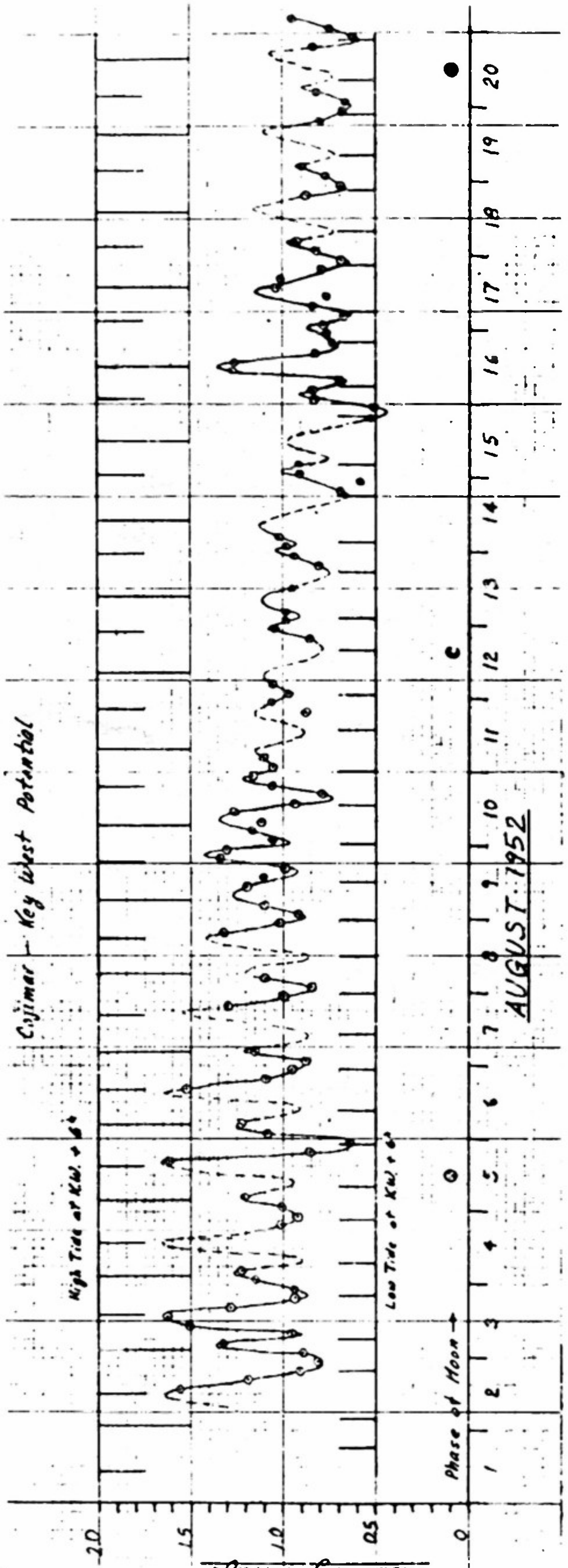

FIG. 9

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has decreased from something like 30 million to 20 million cubic meters per second. Previous studies of the transport through the Straits of Florida made on the basis of navigational data from ships (Fuglister, 1950) indicate that the transport through the Straits of Florida does decrease during the month of August.

It is somewhat surprising to discover from the electromagnetic measurements, however, that most of this decrease of transport appears to occur in less than a week.

As these electromagnetic data are gradually accumulated we hope to be able to discover many features of the hydrography of the Florida Straits.

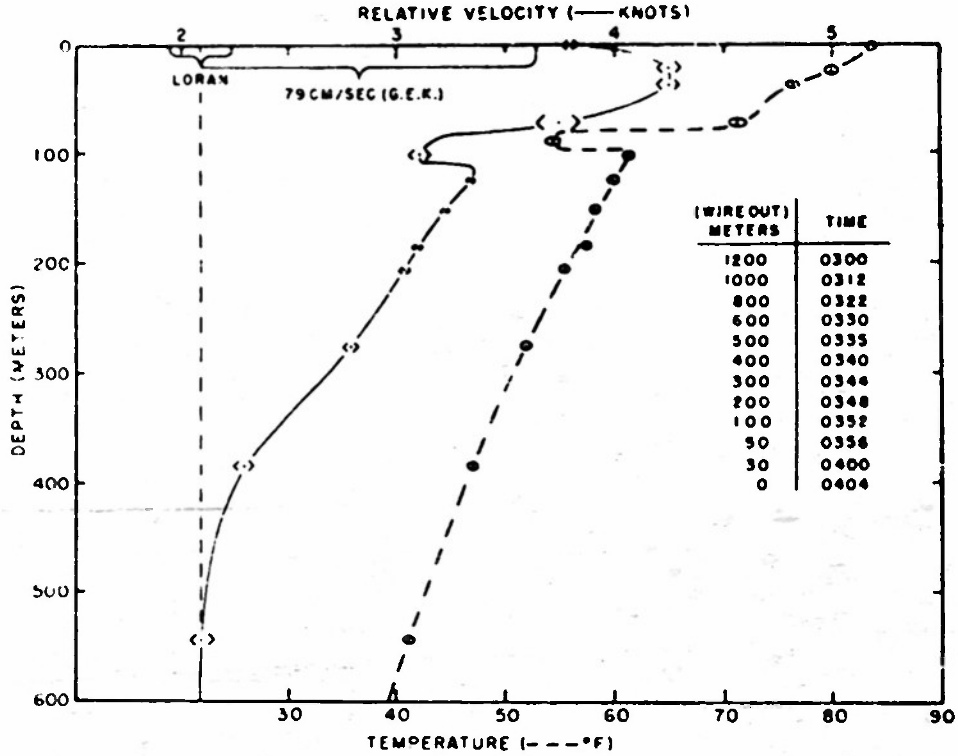
Recording Bathypitometer. Dr. Malkus has submitted a paper to the Journal of Marine Research describing his instrument for measuring the change of velocity with depth within a current. The instrument has now undergone sufficient field testing so that it may now be used as an operational instrument on board our ships.

Direct determination of the change of an ocean current with depth has become an urgent need in oceanographic research, since the vertical structure of a velocity field is perhaps the most sensitive indication of the physical processes which dominate its evolution.

The principal reasons that such direct velocity measurements have not been made extensively is the difficulty of erecting a stable platform for such measurements in a tossing sea. The time element also has to be taken into consideration in making observations with depth for, if the velocity field is continuously fluctuating, a slowly obtained observation might require a longer period than the persistence of the investigated structure at the place of measurement.

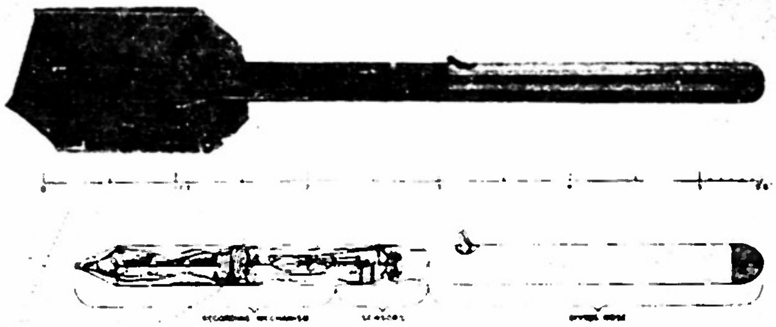
Dr. Malkus was able to design an instrument, using the stability of the weighted end of a cable towed through the sea as a platform for velocity measurement. The instrument is lowered on standard hydrographic wire and utilizes mechanical sensors to record speed, temperature, and pressure on a waxed paper roll.

The following record is presented to clarify the operational use of the instrument and does not necessarily represent a typical section of a current.

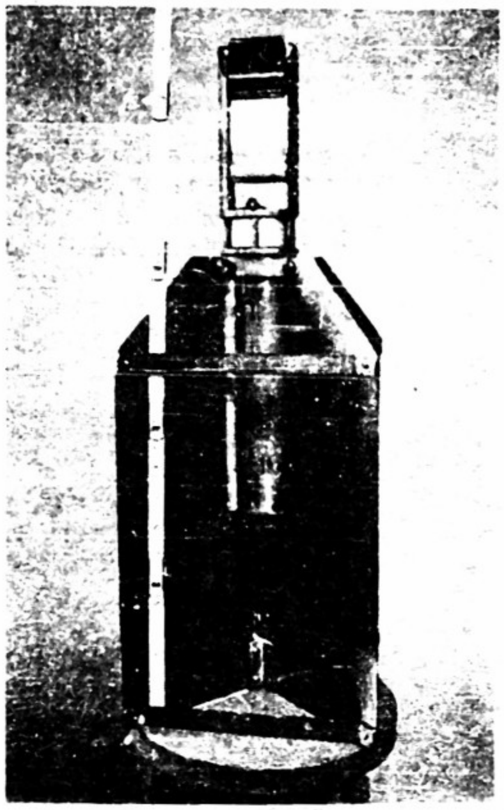


In a northern edge of the Gulf Stream, off Cape Hatteras, the vessel was headed into the current at a surface speed of 3.8 knots. The direction of the surface current was established by a careful G.E.K. observation just before this operation. Three-line Loran fixes were made to ascertain the ship's way with respect to the earth.

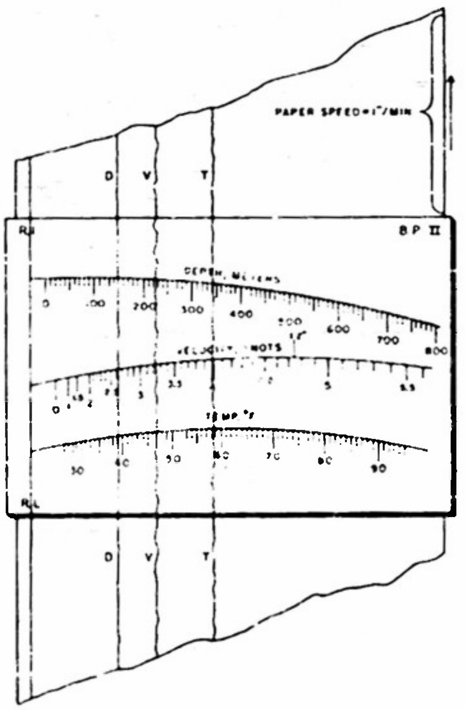
Twelve hundred meters of hydrographic wire were reeled out and the bathypitometer was allowed twenty minutes to swing to its first equilibrium at 542 meters depth. At this time the measurement was assumed to commence. The wire was then retrieved in twelve steps as indicated. The waxed paper was dried and read through a grid to produce this record. It is perhaps significant that fluctuations around the mean at all depths were small and slow. They are indicated on the record by the double-ended arrows at each velocity datum and by ellipses at each temperature datum.



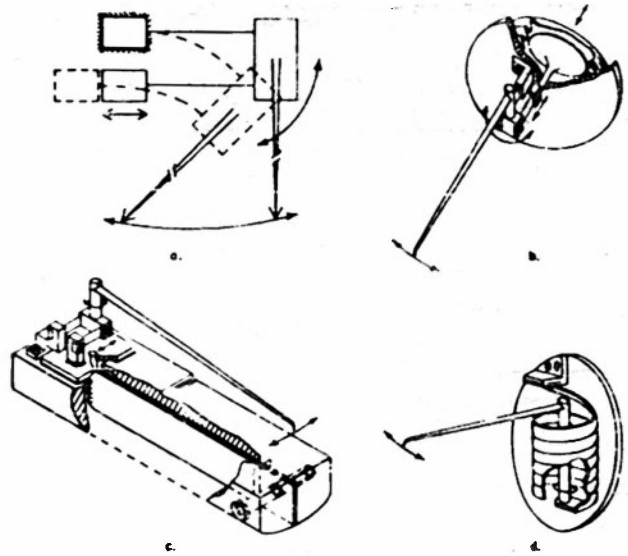
Photograph and schematic drawing of the complete Bathypitotmeter.



The recording mechanism



A sample record from the northern edge of the Gulf Stream.



Detail of the sensors and their couplings: (a) Flexural Amplifier; (b) The Speed Sensor; (c) The Temperature Sensor; (d) The Pressure Sensor.

The Loran observations, with a bracket estimating their probable error, support the indication of the lowest measurement that the water at 500 meters had little or no velocity relative to the earth. The G.E.K. observations, drawn as a square bracket from the Loran "zero", is further evidence that the absolute as well as relative velocity of the stream at each depth was determined. The discrepancy between the indicated G.E.K. surface velocity and actual surface velocity is a measure of the average total transport of fluid at this section (Malkus and Stern, 1952).

The record contains several uncommon features such as the thermal inversion at 90 meters and the maximum in velocity at 30 meters below the surface but shows how such phenomena may be observed and correlated.

Grateful acknowledgment is made of the work of Mr. Angelo Cangiamila, both in preparing the instrument for use and in the observational program. The trouble-free operation must be attributed to the ingenuity of Mr. Myron Howland who is responsible for the instrument's construction.

MODEL STUDIES OF OCEANS

Preliminary work on the circulation on the northern hemisphere oceans has reached a point of satisfactory reducibility under the variety of experimental conditions possible with the present apparatus. While the results remain qualitative, it seems that the experimental variables are now well enough understood for some effort to be directed to the circulations of southern hemisphere oceans. To this end a second paraboloid is to be built which will permit southern hemisphere and northern hemisphere experiments to be undertaken alternately with only as much delay as is required to exchange basins on the drive spindle.

A theoretical study of the dynamics of the circulation in these rotating basin experiments has been completed by Dr. Henry Kierstead. It is hoped that this work (to appear as a technical report) will provide a basis for quantitative studies of the circulation both within models of the ocean basins and within idealized boundaries.

MODEL STUDIES OF ESTUARIES

A paper by Mr. Stommel and Mr. Farmer (WHOI Contribution No. 587) entitled "Control of Salinity in an Estuary by a Transition" has been submitted to the Journal of Marine Research for publication. This paper covers in detail the theory of experimental study and application to estuaries of "overmixing", a term coined to describe the process by which the amount of salt present in an estuary may be determined by the geometry of the mouth of the estuary rather than by the particular nature of the mixing processes inside the estuary.

A hydrographic survey of the Kennebec River estuary was made preliminary to field observations of the detailed nature of the vertical turbulence transport of momentum and salt. The Kennebec estuary has been chosen for these detailed studies of the nature of the mixing process in stratified estuaries because of its simple geometric shape.

Duplicate copies of a card index bibliography on the physical hydrography of estuaries have been prepared and are being distributed to a limited number of active research workers. It is planned to carry this bibliography on a continued basis, adding cards from time to time as reprints are received.

Due to Mr. Ekstrom's illness, work on a salinity measuring instrument in the flume is postponed indefinitely.

MISCELLANEOUS

Salinity Titrations. The following groups of salinity samples have been titrated:

BEAR	14
Great South Bay	57
HAZEL III, Cruises 15 and 16	100
CARYN, Cruise 37	100
Vineyard Sound	27
Miami	124
CARYN, Cruise 42	50
BLUE DOLPHIN	50
ATLANTIS, Cruise 178	1,120
Miscellaneous	30
Total	1,672

Four carboys of water of varying salinities were prepared for the firm of Wallace and Tiernan.

Miss Mary Manning is being trained to do salinity analyses. Due to the resignation of Mrs. Lane, Miss Nelson has assumed charge of the salinity laboratory.

Thermometer Calibrations. Mr. Whitney, working under the supervision of Mr. Bumpus, calibrated twelve reversing thermometers for the University of Miami and twelve for our own use. Work has been started on two unprotected Watanabe thermometers which were sent here for evaluation.

Practically all reversing thermometers owned by or assigned to us have been and still are in the hands of scientific parties at sea, so that further investigation of pressure factors of unprotected thermometers has not been possible. On several occasions during this period, the shortage of reversing thermometers has been felt and, particularly, the shortage of certain ranges of these instruments has been a problem. Negotiations are under way to attempt to arrange for the purchase of a substantial number of additional instruments of German and Japanese manufacture, so as to bring the supply of reversing thermometers up to the level where all the various sporadic or regular oceanographic cruises or projects can be supplied with an adequate number of instruments of the proper types and ranges.

In September Mr. Whitney attended a conference in Washington at the National Bureau of Standards, at which the Taylor Instrument Cos. reported to representatives of the U. S. Navy Hydrographic Office, U. S. Coast Guard, Bureau of Standards, and this Institution on the progress made in their reversing thermometer program. Since April Taylor Instrument Cos. has been engaged in trying to work out certain difficulties and objections in their reversing thermometers. They reported favorable results and, as a result of this conference, are going ahead with further production.

We have been notified that, because of their instructional value, WHOI Reference Nos. 52-29 and 52-30, prepared by Mr. Whitney, are to be incorporated in H.O. Publication No. 607, "Oceanographic Observations at Sea".

BIBLIOGRAPHY

Papers Submitted for Publication. The following papers were submitted for publication:

Malkus, W. V. R.: The heat transport and spectrum of thermal turbulence.

______: A recording bathypitometer. Jour. Mar. Res.

von Arx, W. S.: Notes on the surface velocity profile and horizontal shear across the width of the Gulf Stream. Tellus 4(3).

______: Preliminary results of oceanographic experiments in a rotating basin. Tellus 4(4).

Worthington, L. V.: Oceanographic results of Project SKI-JUMP I and SKIJUMP II in the Polar Sea, 1951-1952. Trans. Amer. Geophys. Union.

Stommel, Henry, and Harlow G. Farmer: Control of salinity in an estuary by a transition. Jour. Mar. Res.

Published Papers. The following paper was publishe(during the quarter:

Kierstead, H. A.: Bottom pressure fluctuations due to standing waves in a deep, two-layer ocean. Trans. Amer. Geophys. Union., 33(3):390-396.

Technical Reports. The following technical reports were distributed during the quarter:

Reference No. 52-63. On the Nature of Estuarine Circulation, PART III (Chapter 7). By Henry Stommel and Harlow G. Farmer. August 1952.

Reference No. 52-71. On the Reality of Internal Lunar Tidal Waves in the Ocean. By B. Haurwitz. September 1952.

PERSONNEL

The following personnel were engaged in either full- or part-time activity under this contract. Not included in this list but contributing to the work were shop workers, maintenance personnel, crews of vessels, and the administrative staff of the Business Office.

Assignment	Name	Title
DIRECTION AND ADMINISTRATION	Ed. H. Smith	Director
	C. O'D. Iselin	Sr. Physical Oceanographer
	A. C. Redfield	Associate Director
	R. A. Veeder	Assist. to the Director
	Jeanne M. Backus	Secretary
HYDROGRAPHIC OBSERVATIONS AND ANALYSES	Nellie Andersen	Senior Technician
	A. B. Arons	Associate in Physics
	D. F. Bumpus	Oceanographer
	A. Cangiamila	Res. Assist. in Engineering
	J. Chase	Res. Assoc. in Oceanography
	L. Ekstrom	Res. Assist. in Chemistry
	H. G. Farmer, Jr.	Res. Assoc. in Engineering
	D. H. Frantz, Jr.	Res. Assoc. in Engineering
	F. C. Fuglister	Oceanographer
	C. R. Hayes	Res. Assist. in Oceanography
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	C. O'D. Iselin, Jr.	Res. Assist. in Oceanography
	J. M. Kemp	Res. Assist. in Oceanography
	H. A. Kierstead	Physical Chemist
	W. V. R. Malkus	Physicist
	W. G. Metcalf	Res. Assist. in Oceanography
	I. I. Schell	Meteorologist
	H. M. Stommel	Oceanographer
	S. L. Strack	Res. Assist. in Oceanography
	L. A. Thayer	Research Engineer
	Evangeline Tollios	Senior Technician
	W. S. von Arx	Oceanographer
	L. P. Wagner	Res. Assist. in Oceanography
	G. K. Wertheim	Res. Assoc. in Physics
	L. V. Worthington	Res. Assoc. in Oceanography
PHOTOGRAPHY, DRAFTING AND TITRATING	F. A. Bailey	Draftsman
	Gloria Gallagher	Multilith Operator
	Mary Manning	Technical Assistant
	Dona Nelson	Technical Assistant

Assignment	Name	Title
PHOTOGRAPHY, DRAFTING AND TITRATING (cont'd.)	D. M. Owen	Res. Assoc. in Oceanography
	F. C. Ronne	Photographer
	Eva Shelnut	Draftsman
	J. W. Stimpson	Draftsman
	Phyllis Vail	Technical Assistant
	G. G. Whitney, Jr.	Senior Technician
	Nancy H. Williams	Technical Assistant

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